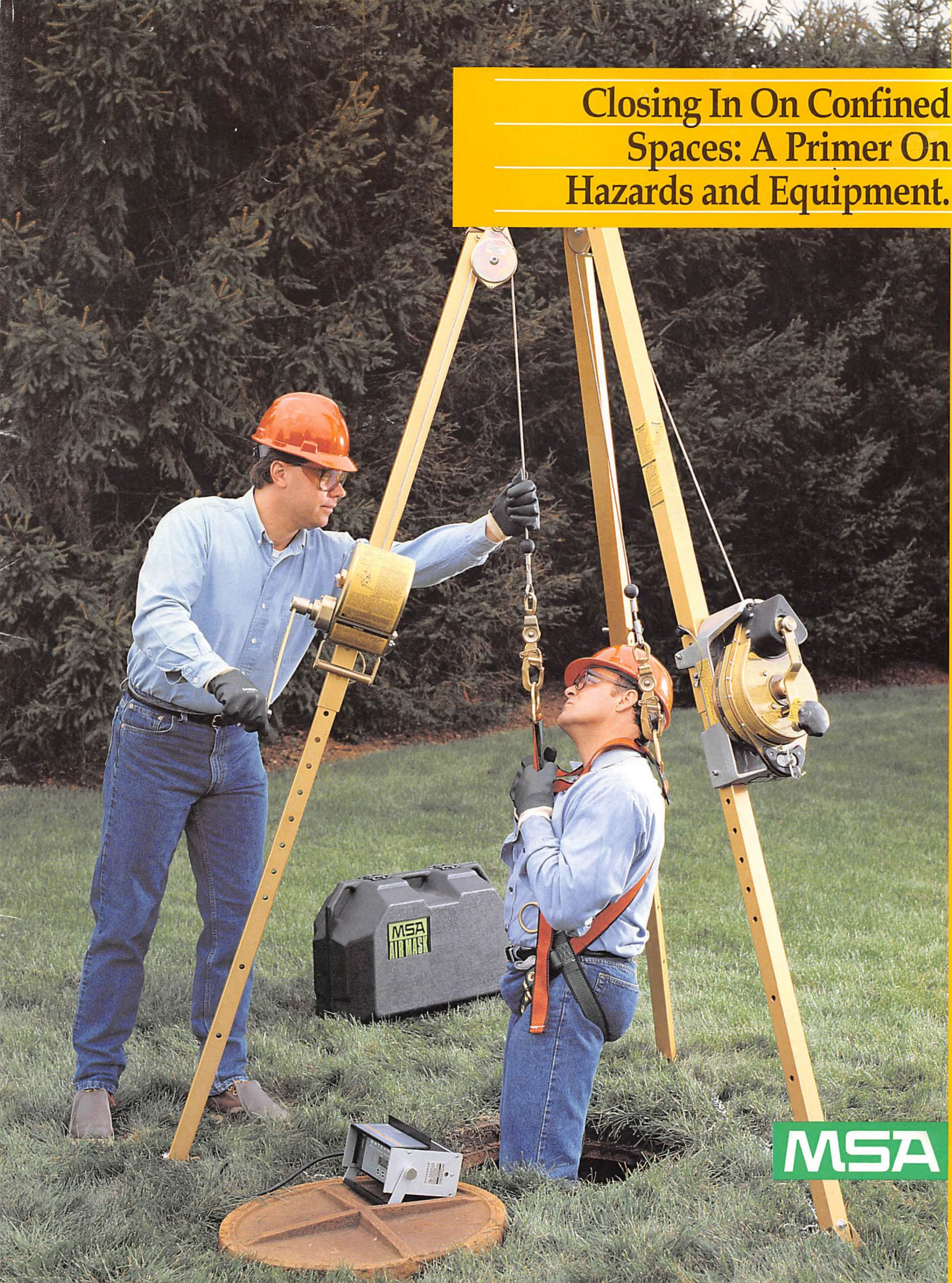
# Closing In On Confined Spaces: A Primer On Hazards and Equipment.




MSA

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For official standards and information on confined space procedures, refer directly to Department of Labor document 29 CFR Part 1910, *Permit-Required Confined Spaces, Final Rule, 1910.146;* Federal Register, January 14, 1993.

MSA

# Worker Protection in a Confined Space.

Confined spaces represent a major health and safety risk for many employees. Being able to recognize and plan appropriately for confined space work can mean the difference between a job well done and disaster.

This Primer presents basic information that can be used as a guideline to develop a confined space work program, with particular emphasis on the selection of appropriate monitoring and personal protective equipment. It is not designed to function as a technical instruction manual, nor is it all inclusive in content or scope.

The Primer is structured to help identify what constitutes a confined space, what hazards can be found in a confined space, how those hazards can impact the worker and what should be done to protect workers functioning in confined spaces.

It also discusses equipment that can be used in confined space applications, ranging from environmental surveillance and monitoring equipment to respiratory protection equipment, protective clothing and lowering and retrieval systems.

For full compliance with the Occupational Safety and Health Administration (OSHA) standard governing confined spaces, 29 CFR 1910.146, it is necessary to rely on the expertise of safety and health professionals, such as industrial hygienists. MSA, with over 75 years of industrial safety experience, can assist in this effort by providing equipment, training and services suited for the special conditions found in confined spaces.

For more complete information, refer to the following publications:

1. Permit-Required Confined Spaces, Final Rule; OSHA, 29 CFR Part 1910.146; Federal Register, Vol. 58 No. 9, January 14, 1993.
2. A Guide to Safety in Confined Spaces, (NIOSH Publication Number 87-113), July 1987.
3. Working in Confined Spaces, (NIOSH Publication Number 80-106), December 1979.
4. ALERT: Request for Assistance in Preventing Occupational Fatalities in Confined Spaces (NIOSH Publication Number 86-100), January 1986.
5. Safety Requirements for Confined Spaces, American National Standards Institute, Z117.1-1989.

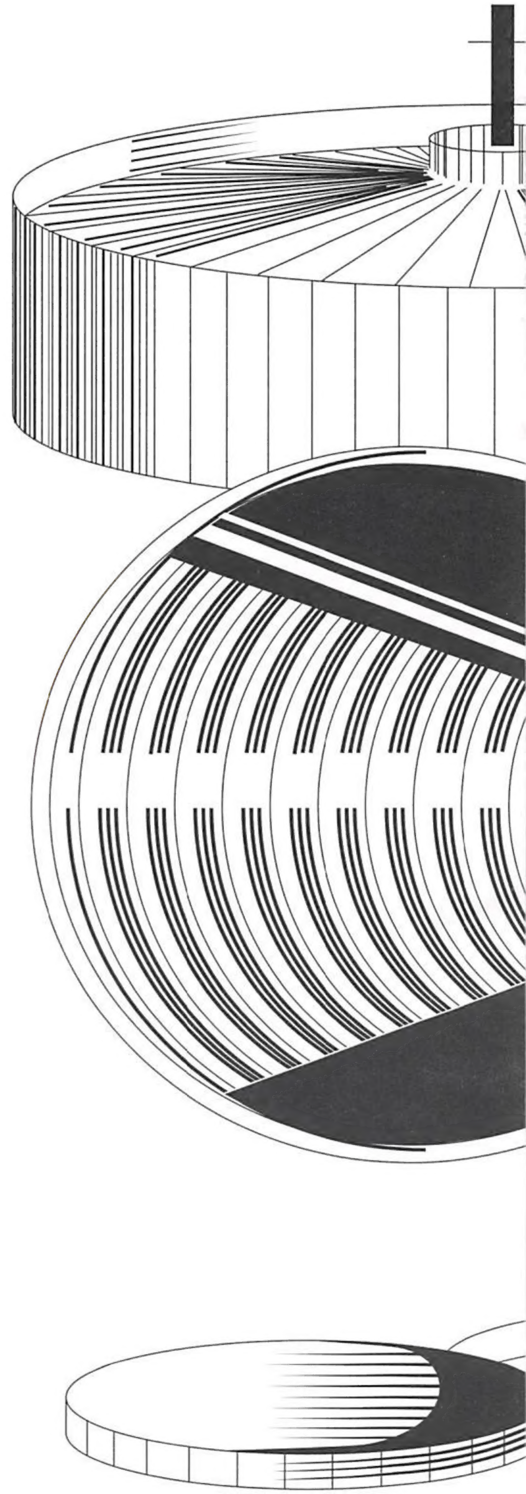
## What is a Confined Space?

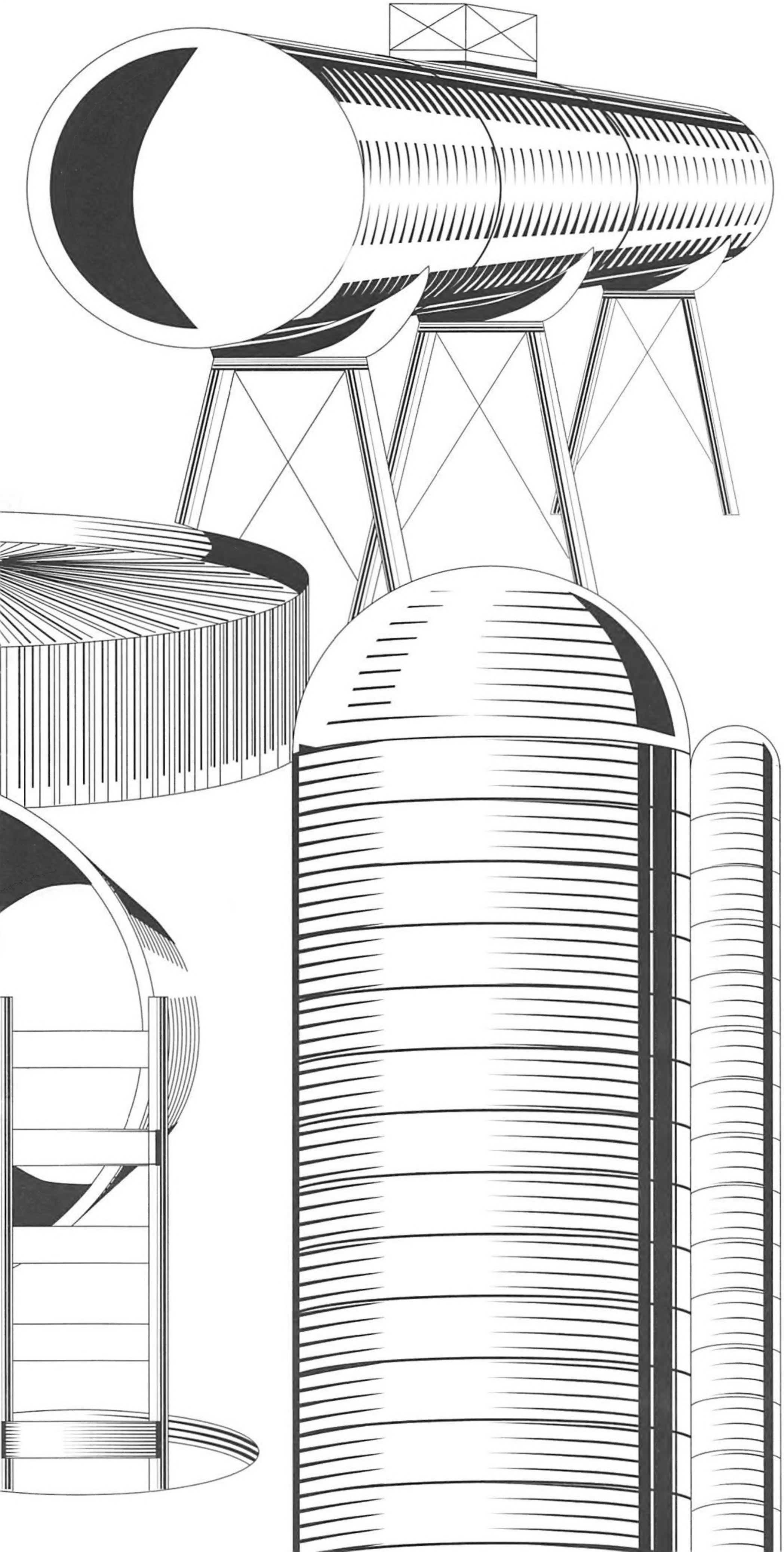
A confined space is defined as an area that:

- Is large enough for an employee to bodily enter and perform work.
- Has limited or restricted means of entry or exit.
- Is not designed for continuous human occupancy.

A **permit-required** confined space is defined as a confined space that has one or more of the following:

- Contains, or has a known potential to contain, a hazardous atmosphere.
- Contains material with the potential for engulfment.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls, or a floor which slopes and tapers to a smaller cross-section.
- Contains any other recognized serious safety or health hazard.





Confined spaces come in many sizes and shapes, and can be found in heavy industry, food, chemical and petroleum processing, utility and communications installations and construction sites, to name only a few. These spaces often are deceiving in appearance. For example, the interior of an open-topped water tower is defined as a confined space, even though the top is open to the outdoor environment. As a rule of thumb, the following areas are typically classified as confined spaces, and should be treated with caution:

- Storage Tanks
- Pump Wet Wells
- Degreasers
- Sewers
- Manholes
- Tunnels
- Underground Vaults
- Boilers
- Silos
- Vessels
- Grain Elevators
- Mixers
- Open-topped Water Tanks
- Water Towers
- Enclosures with Bottom Access
- Railcar Tanks
- Blood Pits at Slaughter Houses

In most cases, these confined spaces are fairly easy to spot. If, however, you encounter an area that has any of the characteristics of a confined space, but is not included in the listing above, it is always best to treat the unknown area and its interior environment like a confined space and to take all necessary safety precautions.

# What Makes a Confined Space Dangerous?

### BY-PRODUCTS OF PREVIOUSLY STORED MATERIALS OR CHEMICALS

Confined spaces used for the storage of petroleum products, chemicals and other substances can often absorb or retain material. When the space is emptied for maintenance, cleaning or other purposes, this absorbed material can leach back out of the walls, changing the composition of the confined space environment.

### ACCIDENTAL LEAKS OR SPILLS

Accidental leaks or spills of such substances as ammonia, acetylene, acids or even plain water can create a variety of hazards within a confined space. These substances can give off fumes and vapors, or can cause reactions that can create sudden and major changes in the confined space environment. These hazards may also contribute to an increased likelihood of "slip, trip and fall" accidents.

### CHEMICAL REACTIONS

Chemical reactions within a confined space may be caused by a variety of circumstances. Manufacturing processes can generate by-products that react with the atmosphere in the confined space to produce a hazardous condition. Cleaning with acids or solvents can give off vapors and fumes that may become a serious health hazard. Similarly, drying paint can create toxic vapors that could pose a serious health threat or react violently with the confined space atmosphere.

### OXIDATION

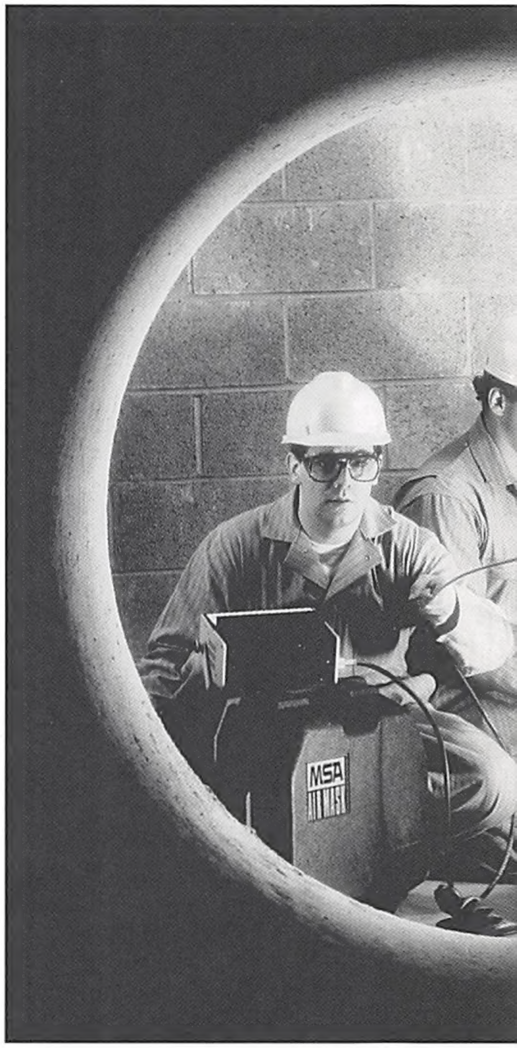
Oxidation processes, such as rusting of metals or the rotting, decomposition and fermentation of organic materials can deplete the oxygen level in a confined space area. Special care should be taken in such atmospheres, because human respiration, combined with oxidation, can quickly reduce the oxygen levels in a confined space below acceptable levels.

### MECHANICAL OPERATIONS

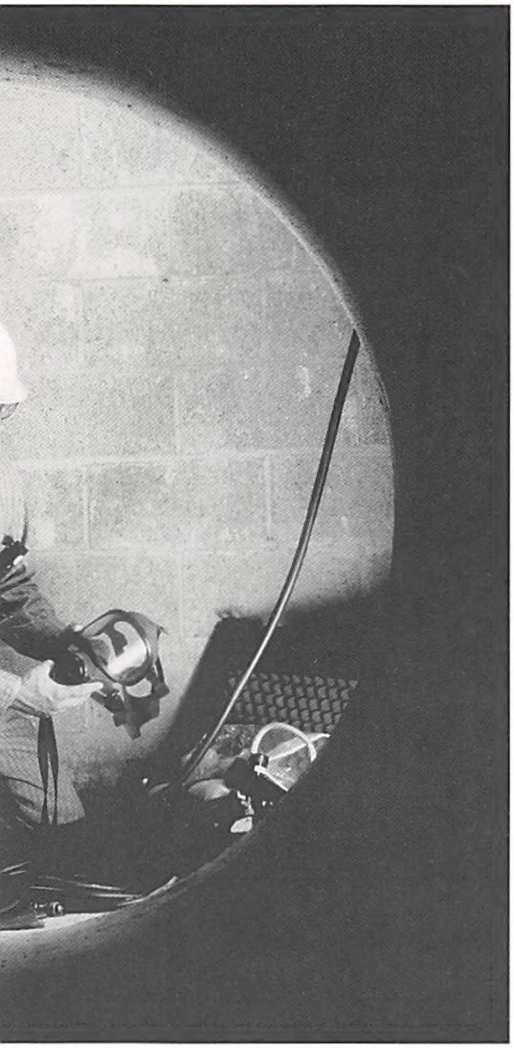
Operations within a confined space, such as welding, painting, cleaning, scraping or sandblasting can generate confined space hazards. Sudden changes in temperature, combined with the release of petrochemical fumes or methane gas, can create unstable environments that may produce volatile reactions. Special care should be taken in spaces such as telephone vaults, basements and tunnels that contain rechargeable batteries. Recharging operations can produce significant levels of explosive gases or toxic gases, which can displace oxygen within the confined space area.

### INERTING ACTIVITIES

Finally, inerting with non-flammable products such as carbon dioxide ($CO_2$), helium (He) and nitrogen ($N_2$) may displace oxygen within a confined space. These products may also combine with other materials in the space to create hazardous substances.



# What Hazards are Found in a Confined Space?



A variety of hazards can be found in a confined space work environment. As a result, careful planning and preparation of all personnel involved in the confined space entry should occur before anyone enters the work area. Hazards can be grouped into one of six groups. They are: atmospheric hazards; physical hazards; engulfment hazards; corrosive hazards, biological hazards; and other hazards.

## Atmospheric Hazards:

Atmospheric hazards are some of the most dangerous, yet frequently unnoticeable hazards found in a confined space. A hazardous atmosphere is an atmosphere which exposes employees to a risk of death, incapacitation, injury or acute illness from one or more of the following causes:

- an atmospheric oxygen concentration below 19.5% (oxygen deficiency), or above 23.5% (oxygen enrichment).
- a flammable gas or vapor in excess of 10% of its lower explosive limit (LEL).
- an atmospheric concentration of any toxic contaminant above the OSHA permissible exposure limit (PEL).
- an airborne combustible dust at a concentration that obscures vision at a distance of five feet or less.
- any immediately dangerous to life or health (IDLH) atmosphere which poses an immediate threat of loss of life; may result in irreversible or immediate, severe health effects; may result in eye damage, irritation or other conditions which could impair escape.

While airborne dust or particle concentrations may be easy to spot with the naked eye, oxygen deficiency or enrichment conditions, as well as hazardous concentrations of vapors or gases must be detected with reliable instrumentation.

### OXYGEN DEFICIENCY

Normal ambient air contains an oxygen concentration of 20.8% by volume. When the oxygen level in the confined space dips below 19.5% of the total atmosphere, the area is considered oxygen deficient. In oxygen deficient atmospheres, life-supporting oxygen may be displaced by other gases, such as carbon dioxide, which results in an atmosphere which can be dangerous or fatal when inhaled. Oxygen deficiency may also be caused by rust, corrosion, fermentation or other forms of oxidation which consume oxygen. As materials decompose, oxygen is drawn from the atmosphere to fuel the oxidation process.

The impact of oxygen deficiency can be gradual or sudden, depending on the overall oxygen concentration, the activity levels of the entrants in the confined space and the concentration levels of other gases in the atmosphere. Typically, decreasing levels of atmospheric oxygen cause the following physiological symptoms:

| % Oxygen | Physiological Effect |
|---|---|
| 19.5 - 16 | No visible effect. |
| 16 - 12 | Increased breathing rate. Accelerated heartbeat. Impaired attention, thinking and coordination. |
| 14 - 10 | Faulty judgment andpoor muscular coordination. Muscular exertion causing rapid fatigue. Intermittent respiration. |
| 10 - 6 | Nausea, vomiting. Inability to perform vigorous movement, or loss of the ability to move.Unconsciousness, followed by death. |
| Below 6 | Difficulty breathing. Convulsive movements. Death in minutes. |

### OXYGEN ENRICHMENT

When the oxygen concentration rises above 23.5% by volume, the atmosphere is considered oxygen enriched, and is prone to become unstable. As a result of the higher oxygen level, the likelihood and severity of a flash fire or explosion is significantly increased.

## COMBUSTIBLE GASES

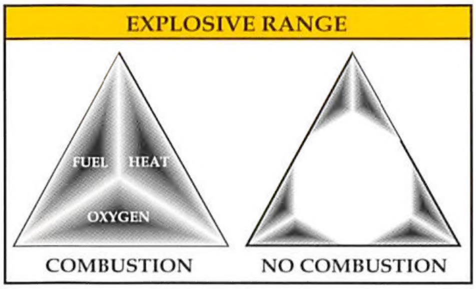



FIGURE 1

In order for combustion to occur, there must be three elements: 1. fuel, 2. oxygen to support combustion and 3. heat or a source of ignition. This is known as the fire triangle (see Figure 1), but if you remove any one of the legs, combustion will not occur.

The percentage of combustible gas in the air is important, too. For example, a manhole filled with fresh air is gradually filled by a leak of combustible gas such as methane or natural gas, mixing with the fresh air. As the ratio of gas to air changes, the sample passes through three ranges: lean, explosive and rich (see Figure 2).

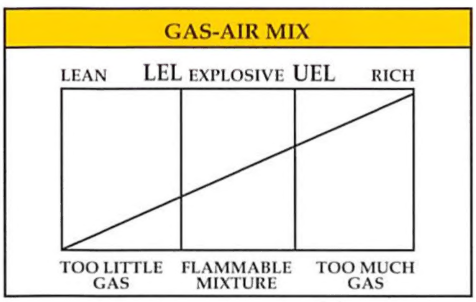



FIGURE 2

In the lean range there isn't enough gas in the air to burn. On the other hand, the rich range has too much gas and not enough air. However, the explosive range has just the right combination of gas and air to form an explosive mixture. Care must be taken, however, when a mixture is too rich, because dilution with fresh air could bring the mixture into the flammable or explosive range. An analogy is the automobile that won't start on a cold morning (a lean atmosphere because the liquid gasoline has not vaporized sufficiently), but can be flooded with too much gasoline (a rich atmosphere with too much vaporization). Eventually, when the right mixture of gas and air finally exists (explosive), the car starts.

## TOXIC GASES

The physiological effects of the following toxic gases common to confined spaces are approximations and will vary according to the health or activity of the individual exposed.

### Carbon Monoxide (CO)

A colorless, odorless gas generated by the combustion of common fuels with an insufficient supply of air or where combustion is incomplete. It is often released by accident or improper maintenance or adjustment of burners or flues in confined spaces and by internal combustion engines.

Called "the silent killer," CO poisoning may occur suddenly.

| PPM Level | Physiological Effect |
|---|---|
| 200 ppm for 3 hours or 600 ppm for 1 hour | Headache and discomfort. |
| 1000 ppm for 1 hour or 500 ppm for 30 minutes | Pounding of heart, dull headache, dizziness, flashes before eyes, ringing in ears, nausea. |
| 1500 ppm for one hour | Dangerous to life. |
| 4000 ppm | Rapid collapse, unconsciousness and death within a few minutes. |

### Hydrogen Sulfide ($H_2S$)

This colorless gas smells like rotten eggs, but the odor cannot be taken as a warning because sensitivity to smell disappears quickly after breathing only a small quantity of the gas. It is often found in sewers or sewage treatment facilities and in petrochemical operations. In addition, $H_2S$ is flammable and explosive in high concentrations.

Sudden poisoning may cause unconsciousness and respiratory arrest. In less sudden poisoning, symptoms are nausea, stomach distress, eye irritation, belching, coughing, headache and blistering of lips.

| PPM Level | Physiological Effect |
|---|---|
| 18 - 25 ppm | Eye irritation. |
| 75 - 150 ppm for several hours | Respiratory irritation. |
| 170 - 300 ppm for 1 hour | Marked irritation. |
| 400 to 600 ppm for 1/2 - 1 hour | Unconsciousness, death. |
| 1000 ppm | Fatal in minutes. |

**Sulfur Dioxide ($SO_2$)**
The combustion of sulfur or compounds containing sulfur produces this pungent, irritating gas. Severe exposures may result from loading and unloading tank cars, cylinders or lines either rupturing or leaking, and fumigation aboard ships.

| PPM Level | Physiological Effect |
|---|---|
| 1 - 10 ppm | Respiratory and pulse rates increase, depth of respiration decreases. |

**Ammonia ($NH_3$)**
A strong irritant that can produce sudden death from bronchial spasms. Small concentrations that do not produce severe irritation are rapidly passed through the respiratory tract and metabolized so that they no longer act as ammonia. If you've ever taken a "whiff" of a household cleaning solution and had it "take your breath away," you have a good idea of the problems that a more severe industrial exposure can present.

Ammonia can be explosive if the contents of a tank or refrigeration system are released into an open flame.

| PPM Level | Physiological Effect |
|---|---|
| 300 - 500 ppm for 30 - 60 minutes | Maximum short exposure tolerance. Eye and respiratory irritation. |
| 400 ppm | Throat irritation. |
| 2500 - 6000 ppm for 30 min. | Dangerous to life. |
| 5000 - 10,000 ppm | Fatal. |

**Exposure Levels for Selected Toxic Gases**

| Substance | *Threshold Limit Value (PPM) | *Short Term Exposure Limit (PPM) | OSHA Permissible Exposure Limit (PPM) |
|---|---|---|---|
| Carbon Monoxide | 25 | – | 50 |
| Hydrogen Sulfide | 10 | 15 | – |
| Sulfur Dioxide | 2 | 5 | 5 |
| Ammonia | 25 | 35 | 50 |
| Hydrogen Cyanide | – | 4.7 | 10 |
| Benzene | 10** | – | 1 |
| Toluene | 50 | – | – |
| Xylene | 100 | 150 | 100 |

* 1996 Threshold Limit Values published by American Conference of Governmental Industrial Hygienists.

**Suspected human carcinogen.

† Short term exposure limit.

**Hydrogen Cyanide or Hydrocyanic Acid (HCN)**

An extremely rapid poison which interferes with the respiratory system of the body's cells and causes chemical asphyxia. Liquid HCN is an eye and skin irritant.

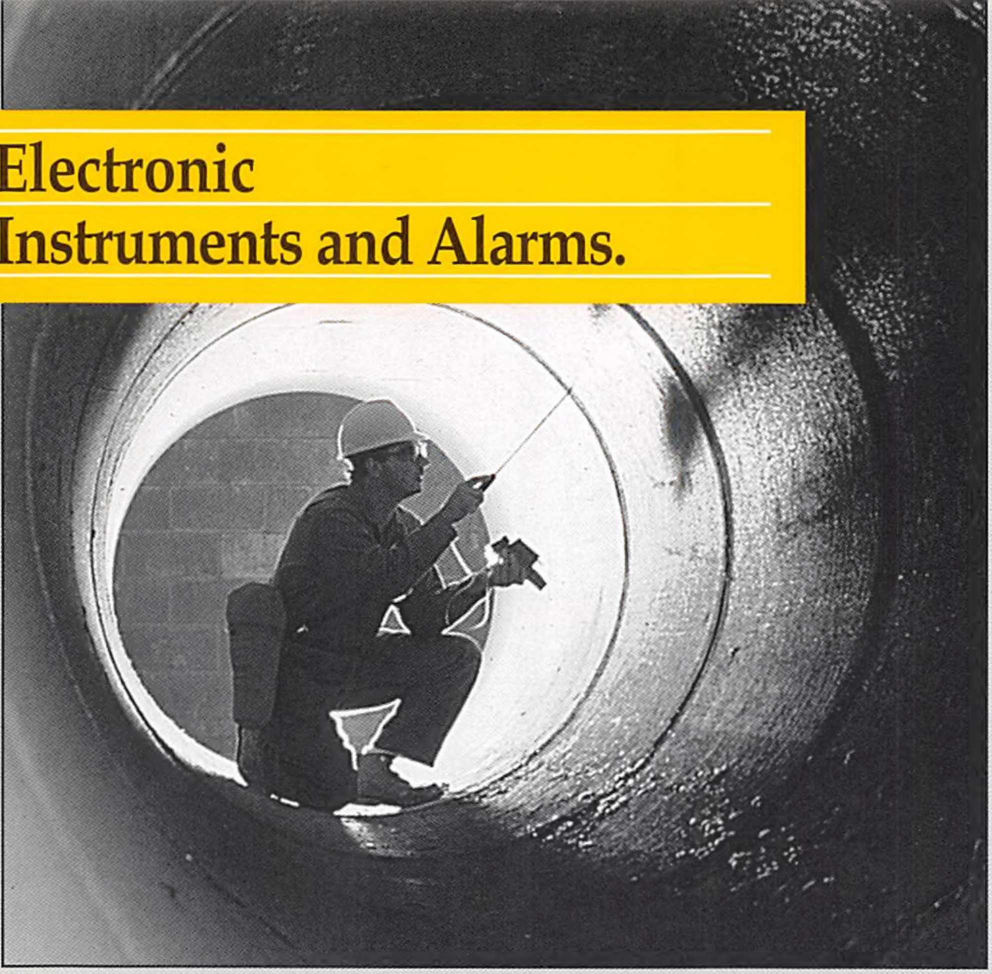
**Aromatic Hydrocarbons (i.e. Benzene, Toluene, Xylene)**

Benzene: a colorless, flammable, volatile liquid with a rather pleasant aromatic odor. Chronic poisoning may occur after breathing comparatively small amounts over a period of time. First sign is exhilaration, followed by sleepiness, dizziness, vomiting, trembling, hallucinations, delirium and unconsciousness.

Toluene: a colorless, flammable liquid whose rather strong aromatic odor warns of high concentrations. It produces extreme fatigue, mental confusion, exhilaration, nausea, headache and dizziness.

Xylene: a solvent mixture that resembles benzene in many chemical and physical properties.

# Electronic Instruments and Alarms.



Battery-powered, direct-reading instruments are considered by many experts to be the most practical devices for conducting spot checks of a confined space atmosphere on a semi-continuous basis. These monitoring devices, which are classified by two groups–single-gas instruments or multiple-gas instruments–typically monitor one or a combination of the following atmospheric conditions:

(1) oxygen deficiency or enrichment;
(2) the presence of combustible gas; and
(3) the presence of certain toxic gases.

Depending on the capabilities of the instrument, monitoring can be conducted simultaneously for oxygen and combustible gas, or for oxygen, combustible gas and toxic gases. These devices are commonly referred to as 2-in-1, 3-in-1, 4-in-1 or 5-in-1 alarms.

No matter which type of instrument is used to check environmental gas concentrations, regular monitoring should be performed during all confined space operations, since a contaminant's level of combustibility or toxicity might increase even if it initially appears to be low or non-existent. In addition, oxygen deficiency can occur unexpectedly.

## Atmospheric Composition:

To determine the composition of a confined space atmosphere, reliable instruments should be used to draw air samples through a weep hole or other small entry port leading into the confined space. If possible, do not open the entry portal to the confined space before this step has been completed. Sudden changes in atmospheric composition within the confined space could cause violent reactions, or dilute the contaminants in the confined space, giving a false low initial gas concentration.

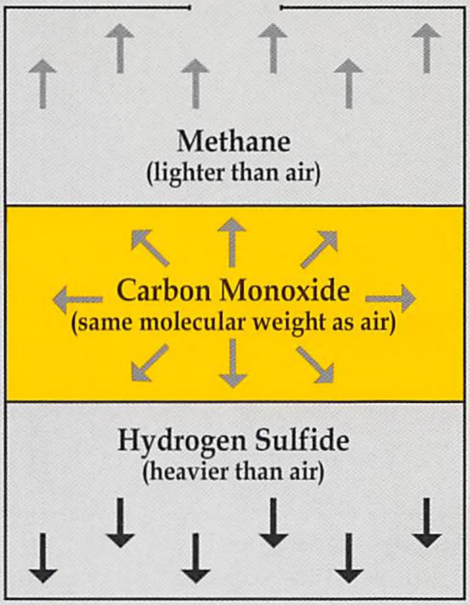



FIGURE 3

When testing permit spaces for acceptable entry conditions, always test in the following order:

1. Oxygen content,
2. Flammable gases and vapors, and
3. Potential toxic air contaminants.

Comprehensive testing should be conducted in various locations within the work area. Some gases are heavier than air, and tend to collect at the bottom of a confined space. Others are lighter, and are usually in higher concentrations near the top of the confined space. Still others are the same molecular weight as air, so they can be found in varying concentrations throughout the confined space. This is why test samples should be drawn at the top, middle and bottom of the space to pinpoint varying concentrations of gases or vapors (see Figure 3). The results of the atmospheric testing will have a direct impact on the selection of protective equipment necessary for the tasks in the confined area. It may also dictate the duration of worker exposure to the environment of the space, or whether an entry will be made at all. Substance-specific detectors should be used whenever actual contaminants have been identified.

It should be assumed that every confined space has an unknown, hazardous atmosphere. Under no circumstances should anyone ever

enter, or even stick his or her head into a confined space for a "quick look." Such an action constitutes entry into the confined space and can expose the entrant to hazardous, and possibly deadly atmospheres.

## HOW COMBUSTIBLE GAS MONITORS WORK

To understand how portable combustible gas detection instruments work, it is first important to understand what is meant by the Lower Explosive Limit (LEL) and Upper Explosive Limit (UEL) (see Figure 2). When certain proportions of combustible vapors are mixed with air and a source of ignition is present, an explosion can occur. The range of concentrations over which this reaction can occur is called the explosive range. This range includes all concentrations in which a flash will occur or a flame will travel if the mixture is ignited. The lowest percentage at which this can happen is the LEL; the highest percentage is the UEL.

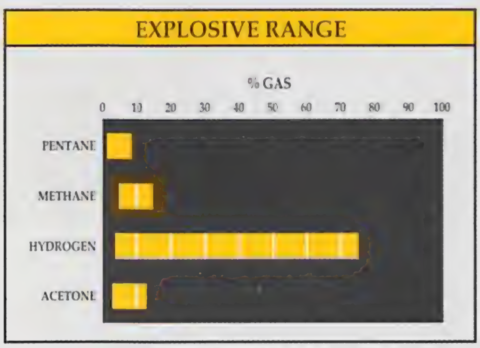



FIGURE 4

Most combustible instruments display gas concentrations in percent of the LEL. Some models have gas readouts in percent by volume and others display both percent of LEL and percent combustible gas by volume. What's the difference? For example, the LEL of methane (the major component in natural gas) is 5 percent by volume, and the UEL is 15 percent by volume. If we slowly fill a room with methane, when the concentration reaches 2.5 percent by volume, it is 50 percent of the LEL; at 5 percent by volume it is 100 percent of the LEL. Between 5 and 15 percent by volume, a spark could set off an explosion.

Different gases need different percent by volume concentrations to reach 100 percent of the LEL (see Figure 4). Pentane, for example, has an LEL of 1.5 percent. Instruments that measure in percent of the LEL are easy to use because, regardless of the gas, you are most concerned with how close the concentration is to the LEL.

## SINGLE GAS MONITORS FOR OXYGEN DEFICIENCY

Oxygen indicators measure atmospheric concentrations of oxygen. Concentrations are generally measured over a range of 0 to 25 percent oxygen in air, with readings being displayed on either an electronic readout or an analog meter.

Oxygen indicators are calibrated with uncontaminated fresh air containing a minimum of 20.8 percent oxygen. With some models, an alarm is activated when oxygen levels drop below 19.5 percent.

*Cricket® Personal Alarms are used both as backup after testing is done with direct-reading instruments, and in non-permit spaces. Models are available for oxygen deficiency, $H_2S$ and CO. The Cricket series requires no maintenance except for routine testing of alarm settings. The devices are lightweight, weighing only 3 ounces.*

## SINGLE GAS MONITORS FOR COMBUSTIBLE GASES

Single-gas instruments for monitoring combustible gases and vapors are generally calibrated on pentane and are designed for general purpose monitoring of hydrocarbon vapors. Such instruments operate by the catalytic action of a heated platinum filament in contact with combustible gases. The filament is heated to operating temperature by an electric current. When the gas sample contacts the heated filament, combustion on its surface raises the temperature in proportion to the quantity of combustibles in the sample. A Wheatstone bridge circuit, incorporating the filament as one arm, measures the change in electrical resistance due to the temperature increases. This change indicates the percentage of combustible gas present in the sample.


*An aspirator bulb on the Explosimeter® Combustible Gas Indicator allows the user to draw samples from either immediate areas or from remote environments. When used with a sampling probe, the Explosimeter Indicator is well suited for drawing air samples from outside the confined space work area. Sampling results are displayed on an easy-to-read analog meter.*


*The MiniCO® and MiniH$_2$S® Responders can be used to measure these toxic gases. The range of these instruments is 0 to 999 ppm. If concentrations exceed preset levels, the instrument triggers audible and visible alarms.*

## SINGLE GAS MONITORS FOR TOXIC GASES

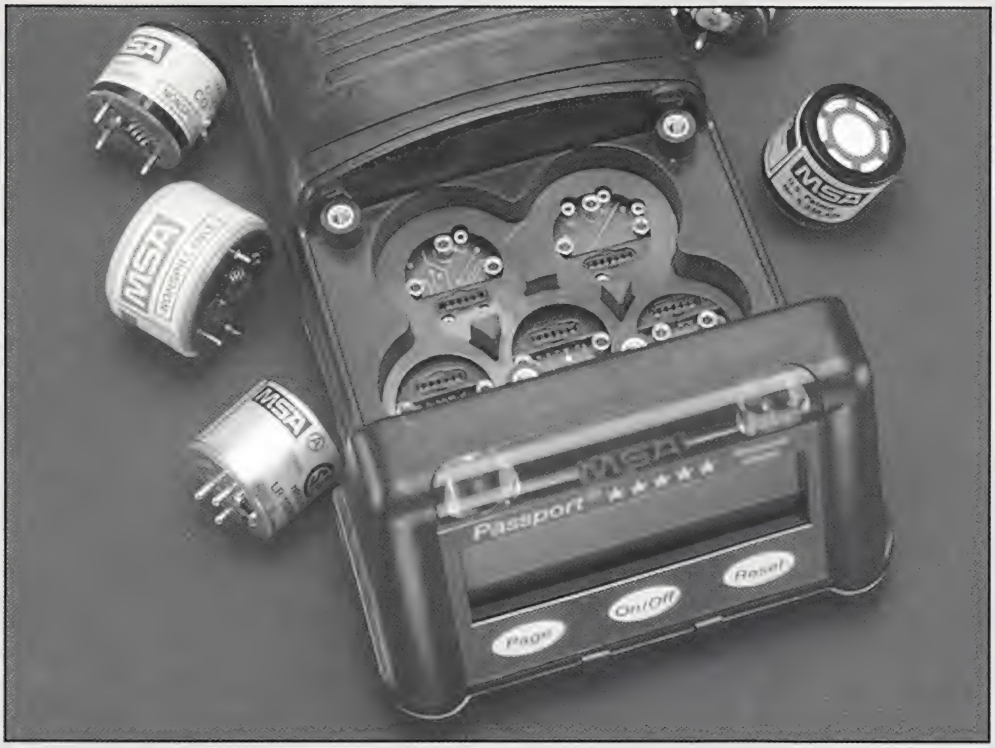
Compact, battery-powered devices can be used to measure levels of carbon monoxide (CO) or hydrogen sulfide ($H_2S$), depending on the model selected. Toxic gas monitors use electrochemical cells. If the gas of interest enters the cell, the reaction produces a current output proportional to the amount of gas in the sample. With these instruments, audible and visible alarms sound if the gas concentration exceeds a preset level. These devices are well suited for use in confined spaces containing motors or engines, which can generate large quantities of CO, as well as in sewers, waste treatment plants and "sour crude" processing stations which tend to have hazardous volumes of $H_2S$.

## MULTIPLE GAS MONITORS FOR OXYGEN AND COMBUSTIBLE GAS

In applications where it is necessary to determine oxygen and combustible gas levels simultaneously, 2-in-1 diffusion-type devices can be used. Sensors measure 0 to 100 percent of the LEL and oxygen from 0 to 25 percent. Remote sampling requires either a pump module or an aspirator bulb adapter.

*The Gasport® Gas Tester is a handheld instrument designed to detect leaks of methane gas (0-5000 ppm plus three precentage ranges: 0-5% and 0-100% by volume and 0-100% LEL); 0-25% oxygen; 0-50 ppm H$_2$S; and 0-1000 ppm CO. Gas utilities use it to check bar holes, survey sites and other locations.*


*2-in-1 diffusion monitoring for oxygen and combustible gas is possible with the MicroGard® Portable Alarm. Concentrations are shown on an LCD readout.*




*The Passport® FiveStarPersonal Alarm is the world's smallest and lightest five-gas alarm. The unit measures combustible gas, oxygen deficiency and up to three toxic gases selected by the user. It is data logging-compatible.*

### MULTIPLE GAS MONITORS FOR OXYGEN, COMBUSTIBLE AND TOXIC GASES

Toxic gases and vapors, which can be inhaled or absorbed through the skin, are frequently found in confined spaces. Sometimes, these atmospheric hazards can also displace oxygen and may incapacitate the body's ability to maintain respiration. Some toxic gases and vapors can also cause long-term physical damage to the body in cases of repeated exposure.

A number of instruments are available to assist in detecting toxic gas. Whereas the pocket size monitors operate by diffusion or an aspirator bulb, larger (but still hand-held) 2-in-1 and 3-in-1 instruments have been developed with built-in pumps to draw samples from the immediate area or from outside the confined space work area when used with sampling lines. For 2-in-1 devices, side-by-side analog displays show percentages for both oxygen and the LEL. With 3-in-1, 4-in-1 and 5-in-1 devices, the user selects either a sensor readout on a digital display or automatic sequential scanning of sensors contained in the instrument. Regardless of the number of sensors selected or the reading being displayed, all sensors should be designed to monitor continuously.

Diffusion-type instruments are available for simultaneously measuring the LEL of combustible gases, oxygen levels and toxic levels (in parts per million) $H_2S$, CO and other toxic gases. Alarms also alert the user to low and high oxygen levels. Remote sampling pump adapters are available to convert these diffusion type instruments into pump-style instruments.


*The Watchman Multigas Monitor is a durable, hand-held instrument used to detect and monitor combustible gases, oxygen and up to three toxic gases. The monitor incorporates the state-of-the-art technology of the Passport® Personal Alarm in a strong, aluminum housing.*

## INCIDENT
### *Puerto Rico*

Workers at a refinery were cleaning a large tank containing the residue from the gasoline and crude oil stored there.

The entry permit required air-supplying respirators, lifelines, explosion-proof lighting and atmospheric tests. However, no one was accountable for permit compliance.

On the day of the incident, permit requirements were generally ignored. No atmospheric testing was done; no lifelines were used; and only 2 of 12 lamps were explosion-proof.

Five employees were in the tank when it exploded. Although it burned for just seconds, workers outside could not help them.

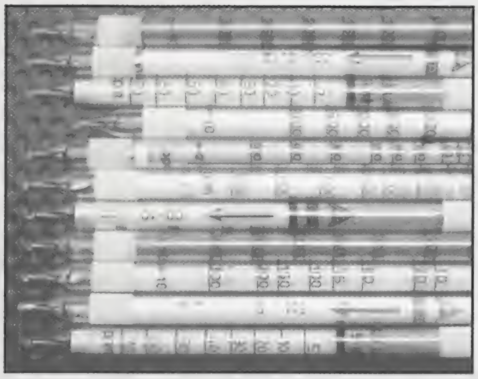

*The Passport® Personal Alarm is the world's best selling five-gas alarm. The unit measures combustible gas, oxygen deficiency and up to three toxic gases. It is data logging-compatible and is offered in both diffusion and pumped versions.*


*The Passport® PID II Organic Vapor Monitor is used for detecting low concentrations of volatile organic compounds. Its operating range is from 0.1-10,000 ppm, and there are graphic and numeric displays. The three button control system makes it easy to use and operate.*


*As an added protective measure, the Passport® FiveStar(shown above), MicroGard®, and Watchman® instruments all have MSA's unique LockAlarm™ feature. If the concentration levels for any of the gases of interest exceed preset levels, the instruments will lock in the alarm mode until the unit is reset. This feature alerts entrants to any changes in the confined space atmosphere while the instrument is operating unattended.*

## PHOTOIONIZATION DEVICES FOR TOXIC GAS AND VAPORS

A photoionization detector, featuring microprocessor technology, uses ultraviolet light to ionize molecules of chemical substances in a gaseous or vaporous state. A real-time digital readout allows the user to make an immediate determination of gas and vapor concentrations. Depending upon calibration input, gas and vapors are measured over a 0.1 to 10,000 ppm scale. Some PID detectors designs are less sensitive to humidity then others.



*MSA/Auer detector tubes are made of glass, have break-off tips and are filled with treated chemical granules for sampling a variety of substances.*

### DETECTOR TUBE SAMPLING SYSTEMS

Detector tube-type devices are recommended for conducting quick evaluations of potential hazards that cannot otherwise be measured. With detector tubes, a known volume of air is drawn through the tube using a manually-operated sampling pump. If gas or vapor is present in the air, chemically treated granules in the tube are stained a different color. By measuring the length of the color stain within the tube, users can determine concentration levels.

Most tubes available today are made of glass, have break-off tips, and are filled with treated chemical granules. They generally have a shelf life of 24 months.

One type of pump frequently used with a detector tube is a compact, bellows-type device. Accurate and repeatable sample flows can be assured by a shaft that guides the bellows during compression. Some models feature an end-of-stroke indicator that lets the user know when a full air sample has been drawn. Models with an integral stroke counter eliminate the tedious recording of multiple pump strokes.

*The Kwik-Draw® Pump, designed for use with detector tubes, draws a precise volume of air for the detection of gases and vapors. Compact and easy to use, the Kwik-Draw Deluxe Pump features a visible stroke indicator that "winks" at the completion of each full stoke. This ensures that the proper volume of air is drawn through the detector tube.*

### CALIBRATION

To ensure the accuracy of gas monitoring and detection equipment, calibration checks should be frequently performed on all instruments used in confined space applications. Depend-ing on the capabilities of the particular instrument, a calibration kit containing a known gas should be used to compare the actual readings of the instrument to the known values of the test gas. If the instrument reading differs significantly from the values of the known standard, the instrument should not be used until it has been adjusted or repaired, if necessary.

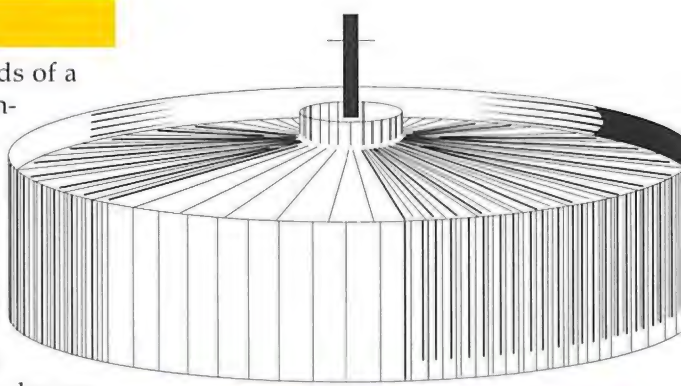
*MSA offers a complete range of calibration equipment to verify the function of all instrumentation used in confined space environments.*

## INCIDENT
## *Oklahoma*

A worker prepared to enter a molasses tank. The atmosphere had not been tested and no respiratory protection, retrieval lines or harnesses were provided. Following a longstanding practice at the company involved, employees removed the tank lid and allowed the tank to "ventilate naturally" for several hours before entering. No testing of the tank's atmosphere was undertaken. The first entrant reported feeling ill as soon as he entered, and collapsed almost immediately. Two "standby" workers, required by the plant's "procedure," entered to rescue him. Each of them collapsed after saying they felt dizzy. All three employees died.

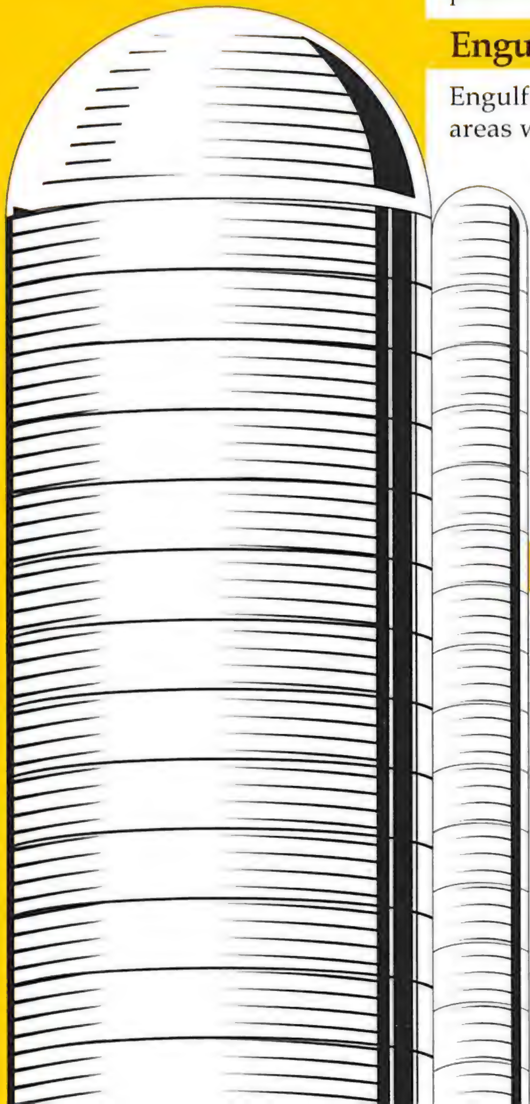
## INCIDENT
*Ohio*

A workman entered the bag house in the dust collection system of a basic-oxygen steelmaking furnace to check the condition of the bags. He stepped onto the dust conveyer, which was not supposed to be operating at the time, and was caught in the machinery. The employee died before rescuers could remove him from the auger pipe conveyer.



### Physical Hazards:

After the atmospheric hazards of a confined space have been identified, it is essential to also pinpoint any physical hazards contained in the work area. Physical hazards, such as grinding equipment, agitators, steam or steam fittings, mulching equipment, drive shafts, gears and other moving parts can pose a danger in confined spaces, in that they can burn, maim or crush entrants in the space. Hazards such as pipe fittings and uneven or wet surfaces may also pose slip, trip and fall hazards.



### Engulfment Hazards:

Engulfment hazards frequently exist in areas where loose materials such as grains, crushed stone, flour or sawdust are stored. Often housed in silos or other containment equipment, these materials harbor air pockets, which can collapse under the weight of an employee. Engulfment hazards either block the employee's airways or compress his/her upper body to the point where suffocation takes place.

### Corrosive Hazards:

Corrosive chemicals, such as acids, solvents and cleaning solutions can pose yet another confined space hazard. Contact between these substances and the skin, mucous membranes or eyes can cause serious irritation or burns. Fumes given off by these materials can also irritate the respiratory system and can cause gastrointestinal distress.

### Biological Hazards:

Biological hazards, such as molds, mildews and spores frequently found in dark, damp spaces can irritate the respiratory system. Bacteria and viruses, found in applications such as sewage treatment, can also threaten the body with a variety of diseases. In addition, bird and animal feces can present serious health hazards to humans.

### Other Hazards:

Other hazards, such as poor visibilty, inadequate lighting and insecure footing can cause significant safety hazards in a confined space. Confined spaces may also harbor rodents, snakes, spiders or insects, which may be dangerous to confined space entrants. Finally, sudden changes in wind or weather can contribute to unexpected variations in the confined space environment.

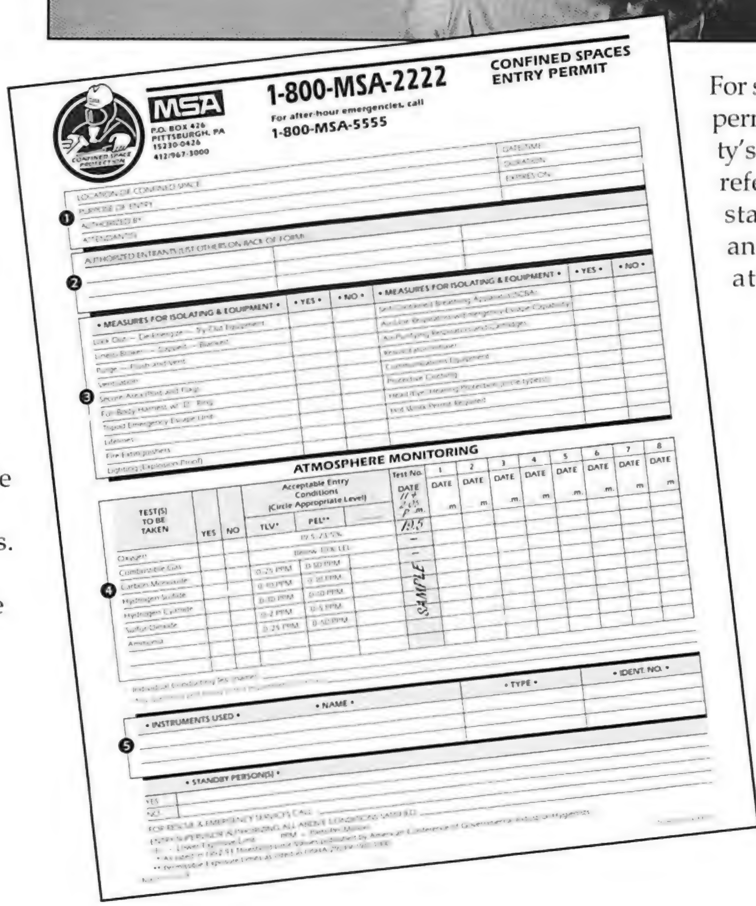
# Procedures for Entering a Confined Space.

Before any employee enters a permit-required confined space, a system of procedures and precautions must be followed. It is essential that supervisors, attendants and entrants all know the specifics of the space. It is also critical to have the correct equipment on hand to ensure worker safety. The following procedures must be followed.

## Completion Of An Entry Permit:

Before anyone enters a confined space, an entry permit must be completed by supervisory personnel. Specifically, the permit must clearly identify:

- The location of the confined space.
- The purpose of the entry into the area.
- The date of entry and the authorized duration of occupancy in the space. A permit may be valid for a period not to exceed that necessary to complete the task or job for which the permit was obtained.
- A listing of authorized entrants.
- A listing of attendants.
- A listing of necessary tools and equipment.
- The signature of the individual authorizing the entry.
- A listing of hazards and acceptable entry conditions.
- Results of initial and periodic tests.
- Measures to isolate the space and eliminate or control hazards before entry.
- A listing of rescue and emergency services.
- Communications procedures.
- Additional permits (hot work) issued.




For specific instructions on permits, consult your facility's procedure manual or refer directly to the OSHA standard. An example of an entry permit is shown at the left.

## INCIDENT *Pennsylvania*

A truck driver was draining sawdust from a 22-foot high bin when he noticed that the flow had prematurely slowed to a trickle, indicating that the sawdust had probably stuck to the walls of the bin. Following the usual practice, he took a pipe, climbed to the top of the bin and climbed inside to knock the sawdust loose. The owner of the bin and the driver had previously discussed the hazards involved in entering the bin. While no formal procedures had been set, the owner had provided a safety line for use when entering the bin. The driver did not use the safety line on this occasion. As he was banging the walls, the sawdust beneath him gave way and he was engulfed in sawdust. When the victim's body was discovered, it was determined that he had died of asphyxiation.

Before any entry into a confined space begins, the individual authorizing the entry must sign the permit. Upon completion of work in the confined space area, the permit is canceled by the entry supervisor, but retained for at least one year for ease of program review. Any problems must be noted on the permit.

For situations requiring "hot work," such as welding, a notation should be added to the confined space entry permit or a separate hot work permit should be attached. The additional information should detail both the scope and duration of the hot work.

To accurately complete the entry permit, and to inform entrants of the hazards contained within the confined space work area, a comprehensive hazard assessment, listing all hazards that could be encountered by entrants during occupation of the confined space, must be conducted before entry. Persons entering confined spaces and those acting as attendants must also know the signs and symptoms of exposure to a hazard. The assessment should then be followed by a document describing the formal method of operation for all occupants of the confined space. This document should explain in detail all cleaning, purging and ventilating practices, as well as safe work practices. It should be reviewed by all people participating in the confined space entry.

A formal safety procedure should also be documented to cover critical safety concerns such as first-aid, showering and decontamination, and obtaining the necessary rescue and medical equipment.

To ensure the understanding of responsibilities and hazards found in a particular confined space, a pre-entry session for everyone involved in confined space work should be scheduled shortly before entry. At this time, each hazard should be discussed with all authorized entrants and attendants, as well as the consequences of exposure to each hazard.

### Ventilation:

OSHA has determined that a complete permit entry program may not be needed for entries into permit spaces that contain **only** atmospheric hazards which can be controlled by ventilation **alone**. These spaces can be made safe for entry if the employer:

1. Demonstrates that the only hazard posed by the permit space is an actual or potentially hazardous atmosphere.
2. Demonstrates that forced air ventilation alone will maintain the permit space safe for entry.
3. Develops monitoring and inspection data to support 1. and 2. (above), and makes the supporting data available to employees.
4. Performs the initial entry to obtain data and subsequent entries in compliance with OSHA 1910.146, paragraph (c) (5) (ii), which includes requirements for periodic testing to assure that ventilation is preventing the accumulation of a hazardous atmosphere.

According to OSHA, spaces with all hazards eliminated can be reclassified as non-permit spaces as long as the hazards remain eliminated. As a general rule, confined spaces should not be ventilated with pure oxygen. Oxygen can react violently with other materials in the atmosphere of a confined space.

## Lockout and Tagout Procedures:

In preparation for entry into the confined space work area, utilities and mechanical equipment serving the space should be isolated and disconnected. Lockout procedures must be performed only by an authorized employee. Pipes and steam lines should be blind flanged in the "off" position and locked out with a padlock. Main breakers to electrical service in the space should be thrown to the "off" position and locked out at the breaker panel. To ensure that the power supply to the equipment has been interrupted, all on-off switches should be tested. Hydraulic lines serving the space should also be blocked and bled to prevent unanticipated movement of the equipment. Finally, if possible, drive mechanisms, gears and belts to all mechanical equipment should be physically disconnected before entry into the confined space area.

Printed tags are used to warn employees that the energy-isolating devices must stay in position and that the tags must not be removed.

# Equipping Personnel for Confined Space Entry.

A wide range of protective equipment is available for protecting entrants to confined space work areas. It is essential that each entrant has the correct equipment for the environment and is versed in its safe and effective use. **Under no circumstances should an employee enter a confined space without the correct training and equipment.**

### TOOLS AND EQUIPMENT

All tools and equipment required to complete the tasks in a confined space must be collected before entry into the space. The lack of proper equipment can pose dangerous situations for workers, and can waste valuable work time. All equipment should be checked before use, and should be in good working order.

Protective measures should be taken to protect people working outside the confined space area. Barricades should be erected to protect passers-by from open manholes, hatch entrances and other unmarked entrances to the confined space area. In addition, care should be taken to prevent the accidental dropping of materials into the entrance of the confined space.

In the case of contractors and subcontractors, all people working in a confined space environment will adhere to the requirements on the entry permit. Deviation from the standards set on the permit will necessitate immediate evacuation of the space.

## Respiratory Protection:

Once the atmosphere of a confined space has been analyzed, it is necessary to select the proper respiratory protection equipment for all entrants working within the confined space.

Types of respirators recommended for confined space operations include SCBA (Self-Contained Breathing Apparatus), dual-purpose SCBA, combination air-line respirators with an escape cylinder, air-purifying devices and escape respirators. Because these devices vary in design, application and protective capability, it is important to first assess the level of contaminants at the work site. Equally important is up-to-date knowledge of the limitations of various respiratory protection devices to ensure proper selection.

### SELF-CONTAINED BREATHING APPARATUS (SCBA)

SCBA provide the highest level of respiratory protection because they are designed to protect workers in oxygen-deficient atmospheres and/or in IDLH atmospheres found in confined space applications. SCBA are equipped with a user-worn air cylinder that offers a dependable, yet limited supply of air without any hoses or tethers to impede movement. SCBA are useful in confined space applications with entrances large enough to accommodate an entrant wearing the apparatus and the cylinder. Low-profile cylinders are available for tight confined space entrances. **Under no circumstances should the entrant enter a confined space that contains a hazardous or potentially-hazardous atmosphere unprotected and wait to have SCBA equipment lowered to him or her.**

Almost all SCBA manufactured today are pressure-demand type devices. The advantage of a pressure-demand device is that it maintains a slight positive pressure in the facepiece, which helps prevent inward leakage of contaminants.

*Self-Contained Breathing Apparatus delivers respiratory protection and mobility in confined spaces. Users have a choice of the regulator mounted on the waist belt (left) or facepiece (MMR model, right).*

Major SCBA components include an air cylinder, low-pressure warning device, regulator(s), facepiece, cylinder, carrier and harness assembly. During operation, the pressurized cylinder air is reduced by the regulator and delivered to the wearer in response to his/her respiratory requirements.

In general, SCBA are available in both low-pressure (either 2216 or 3000 psig) and high-pressure (4500 psig) units. Because air is compressed to about twice the pressure, high-pressure units can have greater storage capacity. This enables longer service life. With high-pressure devices, SCBA users can select either 30- or 60-minute-rated cylinders. With low-pressure units, 30-minute-rated units are used.

One of the latest developments in SCBA technology is a cylinder refilling system which utilizes a special adapter. The adapter makes it possible to quickly refill an air cylinder while the unit is worn, providing the user with a virtually limitless air supply. This configuration also expands the range of uses for SCBA equipment as it eliminates the need to leave the confined space work area to access cascade-type refilling stations.

*The Quick-Fill® System from MSA allows workers to extend the air supply of their SCBA, allowing workers to replenish their cylinder's air supply via a hose from a secondary air source, such as a bank of larger cylinders arranged in cascade fashion.*

## COMBINATION-TYPE DUAL-PURPOSE SCBA

Combination-type devices merge the capabilities of an air-line unit with those of an SCBA. Dual-purpose units differ from conventional SCBA in that they generally have a regulator with two inlet ports – one high-pressure (2216, 3000 or 4500 psig) port for permanent connection to the air cylinder and another low-pressure (85 psig) port for intermittent connection to an air-supply hose. The major advantage of these devices is that they offer the mobility of an SCBA when the air line is disconnected, but also offer the advantage of an extended air supply when the air line is used.

These types of respirators are especially suited for confined space applications. Confined space entrants can "plug" into a primary air source and have a long-duration, uninterrupted air supply. However, users have the option of relying on a 15-, 30- or 60-minute SCBA cylinder if they must move about or leave the confined space.

*Featuring a high-performance, mask-mounted regulator, the PremAire XV Respirator is a combination-type device that includes a pair of compact, waist-mounted air cylinders. The twin cylinders provide a rated service time of 15 minutes of air. The PremAire XV can be used as a 15-minute stand-alone SCBA, or as a combination airline device for added flexibility. This longer-duration air supply and low-profile design make it especially suited for confined space applications.*

## AIR-LINE RESPIRATORS WITH ESCAPE CYLINDERS

Like a dual-purpose SCBA, air-line respirators with escape cylinders "combine" the capabilities of an air-line device with those of an SCBA. However, these devices differ from dual-purpose SCBA in that they generally are equipped with cylinders offering less service time–normally 5- or 10-minute-rated cylinders. Thus, the cylinder can be used for emergency escape purposes only. Combination air-line respirators with escape cylinders offer an apparatus approved for entrance and exit from IDLH atmospheres except with the flexibility of a lower profile and lighter weight needed for confined spaces.

*The PremAire® System from MSA is the most advanced air-supplied respirator available. Designed for versatility, the PremAire Respirator is a full-face, pressure-demand supplied-air device. Its unique waist-mounted manifold allows the supplied-air respirator to be equipped with either a 5- or 10-minute emergency-escape cylinder, a vortex tube for body warming and/or cooling and dual-supply capability–an MSA exclusive that eliminates the need to drag long lengths of air-supply hose around the work area.*

New technology has led to the development of a unique "dual-supply" combination-type respirator. Equipped with a 5-minute-rated cylinder for emergency escape, the unit's regulator features *two primary* air inlets that permit a worker to switch from one air source to another without interrupting air flow and without diminishing the escape cylinder's air supply.

Using the respirator, workers can more easily enter a confined space while "transporting" their own personal air supply–usually a 30- or 60-minute-rated cylinder equipped with a carrying handle. The portable air supply technique works like this:

A worker first enters a confined space breathing via an air line from a larger air source, such as a 300-cubic foot cylinder, located outside the confined space, which is connected to one of the two regulator inlets. After entering the confined space, the "transportable" air cylinder is lowered to the worker using a work winch. The worker then connects to the transportable air source. With this connection made, the worker can disconnect from the original larger air cylinder, relying on the smaller tank as an air source while he or she explores the confined space.

*The PremAire System with the dual-supply option may be used with the TransportAire™ Portable Air Supply to enhance worker mobility. The TransportAire System consists of a handle with nylon straps that fit around an MSA 30-minute cylinder.*

Although this technique could be accomplished using a dual-purpose SCBA, the size and the position of the cylinder on the wearer's back can make it impractical for entering certain tight spaces. Because this technique allows workers to more easily fit through tight spaces, this can become an important part of a company's confined space program.

*Workers entering confined spaces wearing the PremAire Supplied-Air Respirator can use the ESP® Communications System, an electronic speech projection unit in the facepiece for clear voice amplification.*

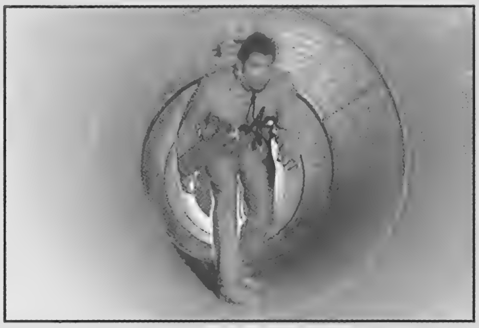
## AIR-PURIFYING RESPIRATORS

Air-purifying respirators are designed for use **only** in atmospheres containing sufficient oxygen to sustain life (at least 19.5 percent) and with known concentrations of gases, vapors and particulates. With these devices, special filter/chemical cartridges are used to remove specific gases, vapors, dusts, mists and fumes from the ambient air. Thus, for the respirator to be effective, the level of contaminants must be within the concentration limitations of the specific respirator and filter. Generally, the useful life of air-purifying respirator cartridges depends not only on the concentration of the contaminants, but also on the breathing volume of the user and the capacity of the air-purifying medium.

**Because of the increased likelihood of oxygen deficiency and due to the possibility of concentrations of contaminants in confined spaces suddenly changing or not being fully known, air-purifying respirators should not be used for confined space entry unless known conditions exist and can be maintained.**

## ESCAPE RESPIRATORS

Escape respirators provide a means of escape from IDLH atmospheres. These lightweight units generally are carried by the worker and feature a 5-minute air cylinder that delivers respirable air to the hood. Escape respirators must be able to provide a minimum air flow of 72 liters per minute. The hood is typically made of a flexible material, such as urethane, and can be used in temperatures as low as 0° F. For improved performance in chemical environments, transparent and flexible hoods manufactured from Teflon* material are available. Escape respirators must **never** be used to **enter** a confined space. As their name implies, they are for escape only.



*The Custom Air V® Escape Respirator provides a means of escape from IDLH atmospheres. A lightweight unit, it delivers a high flow rate of compressed air to the flexible hood, supplied by a five-minute-rated cylinder.*

## Head, Eye, Hearing and Hand Protection:

Confined spaces often present hazards that require head, eye, hearing and hand protection. A wide range of equipment, made from a variety of materials, is available for confined space applications. Special care should be taken to ensure that all areas of the body are protected before entering a confined space work area.

### HEAD PROTECTION

Head protection most commonly takes the form of a protective hat or cap and should meet the performance requirements of ANSI Z89.1-1986. Designed for top impact protection, as well as to dissipate the impact of bumping into stationary objects, protective headwear is frequently made of high density plastic. The hat or cap shell is supported by an inner suspension that creates an "impact space" between the crown of the user's head and the interior of the headwear. For maximum protection, no confined space worker should be allowed to enter the work area without head protection.

*V-Gard® slotted caps offer head protection, while accommodating hearing protection, faceshields or welding helmets.*

### EYE PROTECTION

Eye protection, in the form of protective spectacles with sideshields or goggles, helps shield workers' eyes from airborne debris. For additional protection, full faceshields are available to protect the eyes and other areas of the face from splashes and flying debris. Made for use with protective headgear, faceshields must be worn over suitable primary protectors such as spectacles or goggles.

*The Chemgard® EC Faceshield Assembly is used in applications demanding eye and full-face protection against flying abrasive particles, flying objects and chemical splashes. The corrosion-resistant frame is made of durable plastic with no metal parts. Sightgard® Spectacles feature a universal bridge and temple, including integral side shields and hard coated polycarbonate lenses.*

### HEARING PROTECTION

Hearing protection equipment provides auditory protection from noises commonly generated in confined spaces. Due to their configuration, confined spaces tend to reverberate and amplify even small sounds, creating a serious auditory hazard for the worker. Aural protectors frequently take two forms; flexible plugs that insert into the worker's ear canals or ear muffs that cover each ear. Ear plugs or ear muffs should be worn in environments where cutting, grinding or high levels of mechanical noise are present. Muffs are worn with the headband. When head protection is worn, the headband fits under the chin or behind the head. Other models that snap into hard hats are also available.


*Noisefoe® Mark IV Ear Muffs, as well as Ear Defenders® II Aural Protectors, create an effective seal against long-term exposure to the harmful noise frequently found in confined spaces.*

## Communications Equipment:

It is critical to have the correct communications equipment in any confined space work area. Reliable communications equipment allows workers to communicate between themselves, as well as with the attendant stationed outside of the work area. In the event of an emergency, communications equipment allows help to be summoned quickly.

*VARI-Clear™ Personal Communications Systems are NIOSH-approved for use with a variety of respirators. Designed for short-range communications, as well as radio interface, VARI-Clear Systems feature optional voice-activated operation (VOX) for hands-free operation.*

When working in a confined space atmosphere, contact must be maintained between the workers in the space and the attendant stationed outside. Battery-operated, voice-activated communications systems are frequently used, as they allow the worker to move freely in the confined space, and eliminate the need to hand-operate the communications device. Special care should be taken to ensure that batteries for all communications devices are in good working order, and that the range of the devices is sufficient for transmission from any part of the confined space work area. Lines of contact should also be established outside the confined space area to summon rescue personnel, if the need arises.

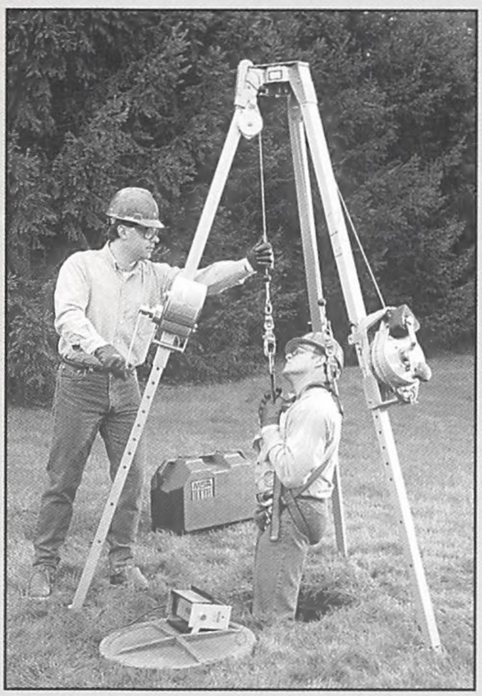

*The Firefly® II Personal Alert Safety System (PASS) from MSA is a durable, compact and lightweight personal alarm that signals for help if the wearer becomes disabled. The Firefly II unit features a patented motion detector that detects minimal wearer movement. If no movement is detected for approximately 20 seconds, a low-level prealarm is sounded. If the worker still has not moved after the alarm period, a 98-decibel alarm alerts observers. It is also available with a heat sensor, and is certified to NFPA Standard 1992 (1993 edition).*

Body alarm devices, frequently used by the fire service, are also useful in confined spaces where communication between workers and attendants is difficult. Designed to sound if the wearer does not move during a specified period of time, the alarm alerts other workers, as well as the attendant, that a worker is not moving and may have been overcome. This allows the attendant to clear the confined space and summon help.

## Confined Space Entry and Retrieval Equipment:

To facilitate both entry into and exit from a confined space, it is necessary to have a proper retrieval system for both workers and equipment. Consisting of a heavy-duty lifeline, a tripod and a personnel/material hoist, retrieval equipment is useful in lowering workers into a confined space environment, as it controls the rate of descent and prevents accidental falls into the work area. Additional work hoists are frequently used to raise and lower tools and equipment.

If an employee must be quickly extracted from the confined space, lifting equipment employs the concepts of physics to raise the entrant out of the work area. Hoists typically have a mechanical advantage of 25:1. It is nearly impossible for an average person to pull someone out of a deep manhole without this mechanical advantage.

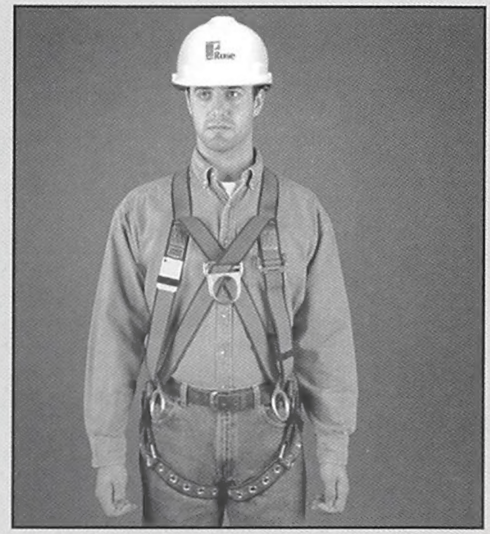


*Fall Rescue™ Work System allows employees and tools to be lowered into confined spaces easily and quickly. Portable, the Fall Rescue System consists of a tripod assembly, a self-retracting lanyard with emergency rescuer, a pesonnel/materials hoist and a carrying bag.*

*The Dyna-Hoist System is a rugged, versatile and economical Hoist for lifting, lowering and positioning of personnel and materials. Designed for a maximum work load of 310 lbs for personnel (10:1 design factor) and 620 lbs for materials (5:1 design factor). All steel construction with an internal shock absorber that operates even when usable length of line is fully extracted. Load-limiting clutch prevents loading hoist in excess of 620 lbs. Optional emergency drive allows manual bypass of the load-limiting clutch for extra lifting capacity.*

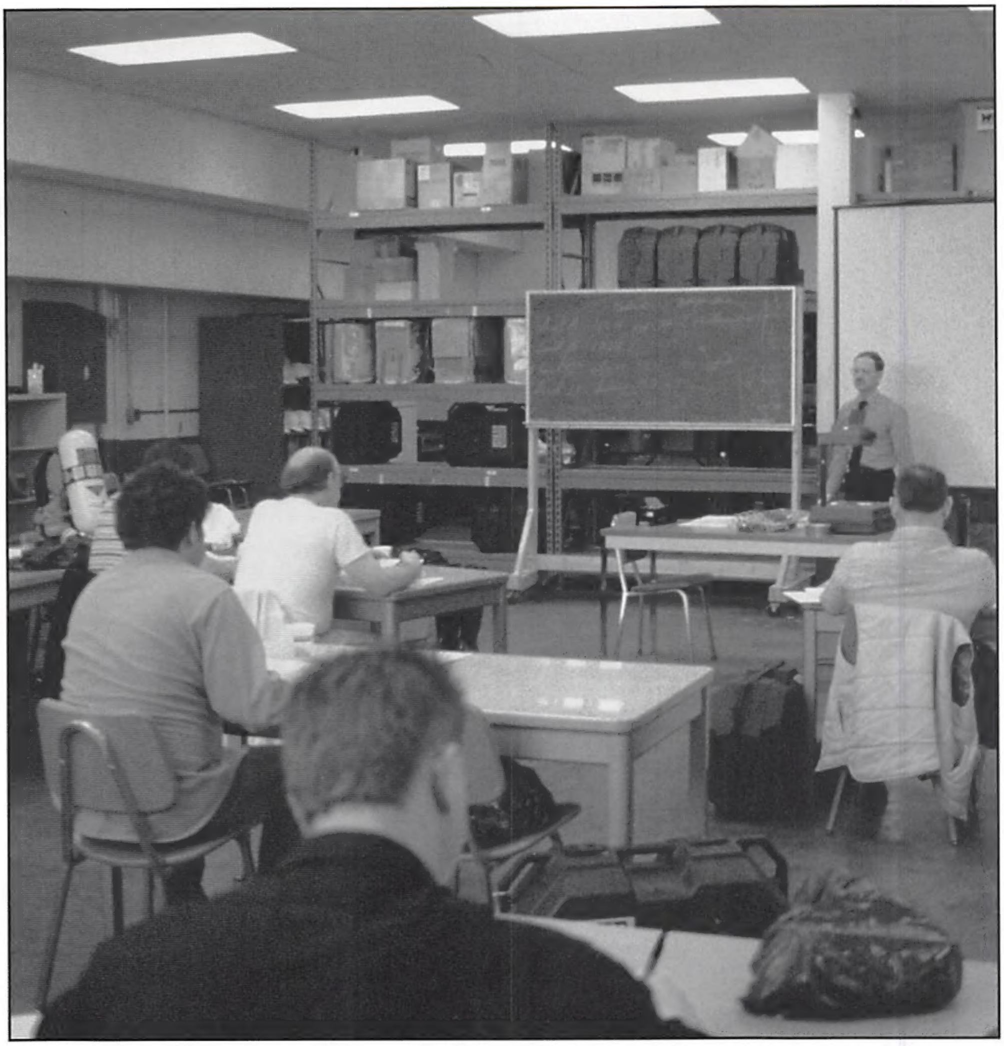
Hoists on lifting equipment should be outfitted with durable retrieval lines, and should be self-braking to prevent free falls and to hold personnel in place when raising and lowering has stopped. Tripods should have two hoists; one for lowering, arresting and retrieving a worker and a second hoist for raising and lowering tools or equipment to the worker. This means a worker is **never** tempted to disconnect from his/her lifeline. Before entry into confined space work areas, all equipment should be carefully inspected. **Harnesses or retrieval lines showing any signs of wear should not be used.**

A wide variety of harnesses are available for use with retrieval equipment. Shoulder, back or chest D-rings may be used as attachment points for retieval lines. For emergencies in confined spaces with extremely tight openings, wrist-type harnesses allow downed workers to be quickly extracted from the work area by pulling the arms over the head and then raising the worker with a tripod and hoist. This arrangement helps to protect the injured worker's head and reduces the possibility of the downed worker's shoulders catching on the entry port to the confined space.



*The Pullover harness uses a patented design which eases donning and doffing. A single point shoulder strap adjuster and the choice of Qwik-Fit™, tongue or friction thigh straps buckles, to adjust the harness snugly to the body. Integrated systems (harnesses with shock absorbers) are available upon request. All Pullover harnesses meet or exceed ANSI Z359.1, ANSI A10.14, CSA and OSHA requirements.*

# Training Entry Personnel and Attendants.



*All personnel involved in the confined space entry, including supervisors, entrants, attendants and rescue personnel, should be well trained.*

Individuals authorizing entry into a confined space must have a complete knowledge of the contents and hazards within the space.

Every worker must fully understand their duties before ever working in the confined space or if there are changes in the assigned duties or confined space applications. The training must be certified. Specifically, the employer should ensure that confined space entrants are familiar with:

- Hazard Recognition. The employer must let the entrant know what hazards are contained in the confined space, and the consequences of exposure to those hazards. In addition, the employer must inform the entrants of the signs and symptoms of exposure to the hazards contained in the confined space.
- Communication. The employer must ensure that authorized entrants maintain contact with the attendant stationed outside the confined space work area.

  The attendant is alerted when the entrant recognizes a warning sign or symptom of exposure to a dangerous situation, or detects a prohibited condition.
- Protective Equipment. The employer must make sure that employees have all necessary personal protective equipment and instruments, including external barriers to protect entrants from external hazards.

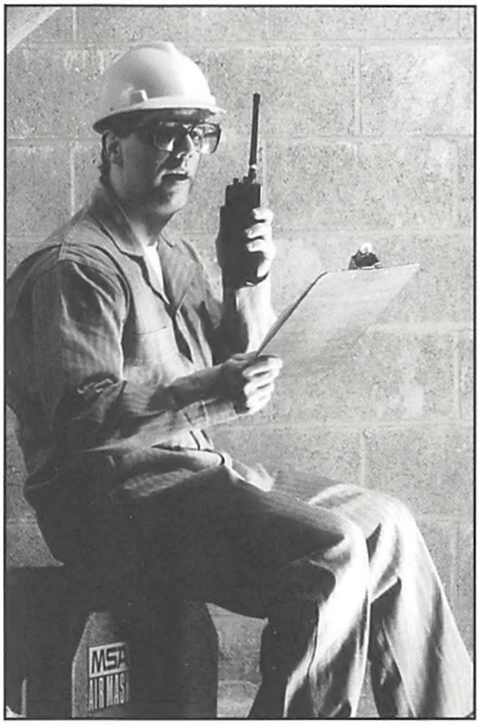
Workers must be instructed in the proper use and donning of protective equipment, as well as the proper operation of instruments that must be used in the confined space. Specifically, each worker needs to know what equipment is available, where to get it and how to use it properly. Workers should also be trained in the proper use of communications equipment in order to maintain contact with the attendant and to notify co-workers of any hazardous situations or sudden changes within the confined space.

- Self-Rescue. The employer must ensure that there is safe entry and exit from the confined space work area. Entrants should leave the work area when:
  1. The attendant orders evacuation.
  2. The entrants recognize a warning sign or symptom of exposure to a dangerous situation.
  3. The entrants detect a prohibited condition.
  4. An evacuation alarm is activated.

Employees must become familiar with the procedures for self-rescue.

### ROLE OF THE ATTENDANT

All workers in a confined space must be observed by an attendant located outside the confined space work area. The attendant must remain on duty at all times during entry operations.




Specifically, the attendant must oversee:

- Number of Entrants. It is the attendant's responsibility to maintain an accurate count of all workers in the confined space.
- Hazard Recognition. The attendant must know and be able to recognize all potential hazards connected with the confined space. In addition, the attendant must monitor all conditions both inside and outside the confined space work area in order to determine if occupation of the confined space is safe.
- Communications. The attendant must maintain effective and continuous contact with every entrant in the confined space during entry. In addition, it is the attendant's responsibility to order all entrants out of the space when: conditions not allowed on the entry permit occur; the attendant notices behavioral changes in the entrants; an uncontrolled hazard within the permit space occurs; the attendant notices a condition outside the permit space that could endanger entrants within the work area; or the attendant must leave his post in the event another confined space monitored by the attendant has an emergency.
- Securing the Area. The attendant is also charged with keeping unathorized personnel from entering the area. If unauthorized personnel enter the vicinity of the confined space area, it is the attendant's responsibility to instruct them to leave. If unauthorized personnel enter the confined space work area itself, the attendant must notify entrants, as well as supervisory personnel of their presence.
- Coordinate Rescue. In the event a worker is overcome, the attendant must order all workers from the confined space, summon help and coordinate all necessary rescue efforts. Help may come from either in-house rescue or emergency services or a community emergency response team. The attendant may perform non-entry rescues as specified by the company's rescue procedure. **Under no circumstances should the attendant ever enter the confined space. More than 60% of all confined space fatalities occur because an attendant or an unauthorized person rushes into the hazardous environment without protective equipment.**

Some companies outfit the attendant with the proper personal protective equipment and instruments necessary to make a rescue. In this situation, the attendant is "on stand-by" in the event that a rescue is necessary. However, in these situations, a rescue entry must not take place until a back-up attendant for the original attendant arrives.

## After Entry is Complete:

Once a confined space entry has been completed and all personnel have left the work area, the confined space should be secured and the entry permit canceled.

### RECORDS

Canceled entry permits, including notes of problems encountered, must be retained for at least one year. There must be an annual review of the permits, and the program revised as necessary. Comprehensive records documenting all training activities, safety drills, equipment inspections, atmospheric test results and equipment maintenance should be kept for every entry into a confined space area. These records will help ensure that proper procedures were followed, and that safety requirements of the confined space have been properly addressed.


## TOLL-FREE NUMBER:

MSA offers customers a toll-free telephone number that, during work hours, will put you in touch with the MSA Customer Service Center. For after-hours emergencies, call 1-800-MSA-5555 and MSA Headquarters will assist you.

# 1-800-MSA-2222



Offices and Representatives in principal cities worldwide.
**In U.S. call the Customer Service Center toll-free at 1-800-MSA-2222.**
**To reach MSA International, call (412) 967-3354 or fax (412) 967-3451.**
**Visit our web site at www.MSAnet.com**

Corporate Headquarters: P.O. Box 426, Pittsburgh, PA 15230

**Note:** This Bulletin contains only a general description of certain MSA products. While some uses and performance capabilities are described, under no circumstances should the products be used except by qualified, trained personnel, and not until the instructions, labels or other literature accompanying the product have been carefully read and understood and the precautions therein set forth followed. Only they contain the detailed information concerning these products.

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